NUI Galway
OÉ Gaillimh

Semester 2 Examinations 2012/ 2013

Exam Code(s)	4IF
Exam(s)	B.Sc. in Information Technology
Module Code(s)	CT420
Module(s)	Real-Time Systems
Paper No.	1
Repeat Paper	N
External Examiner(s)	Prof. Michael O'Boyle
Internal Examiner(s)	Prof. Gerard Lyons Dr. Michael Madden *Dr. Hugh Melvin *Dr. Michael Schukat

Instructions: Answer 2 questions in section A and 2 questions in section B. All questions carry equal marks.

Duration	3 hours
No. of Pages	6
Discipline	Information Technology

Requirements:

MCQ
Handout
Statistical/ Log Tables
Cambridge Tables
Graph Paper
Log Graph Paper
Other Materials

Release to Library: Yes [X] [ ]

Section A

Q1

(i) TCAS (Traffic Collision Avoidance Systems) are fitted to commercial airplanes to minimise the risk of in-flight collisions caused by Air Traffic Control or pilot error. Essentially TCAS ensures that planes on a collision course will **automatically** communicate with and ultimately avoid each other.

Using this example, distinguish between, and give estimates for both the Sample Time and Response Time of the TCAS system, and show how these terms are related. You can assume that max speed of both planes is 600 kilometres per hr which in a worst case scenario means a relative closing speed of 1200 kilometres per hr , and also that it takes approximately 20 seconds for a plane to make the necessary physical position change.

[15]

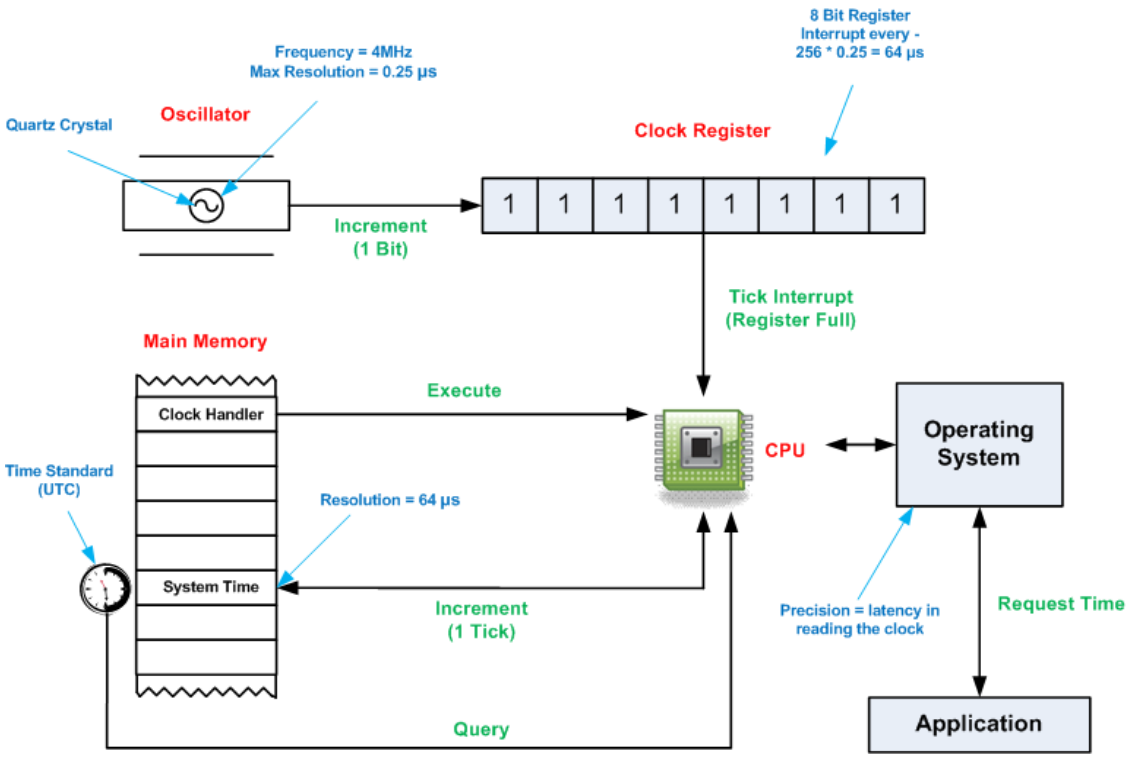
(ii) The diagram below outlines a high level view of a typical computer system clock. Describe in some detail how it operates.

[10]

Comment also on how clock granularity can impact on the following-

- Fault diagnosis in a distributed system using timestamped log files
- Operating system responsiveness via timeslicing of processes

[10]



(iii) Most hard RTS eg. Moneypoint Power Station Controllers use a cyclic executive approach to scheduling . Briefly explain why.

[5]

Q2

(i) Distinguish briefly between **time and timing** synchronisation.

[5]

(ii) Using each of the following examples, explain firstly - whether time, timing, or both types of synchronisation are important and secondly - outline the level of synchronisation required:

- Electrical Power Line Fault Detection System
- Maintaining Lip synchronisation across a WAN
- MMOG (Massively Multiplayer Online Gaming) Server servicing players from across the globe

[15]

(iii) Your company wishes to install its own NTP time server to service a range of its local LAN applications requiring synch levels better than 5 msec. You are asked to decide on the choice of remote NTP servers with which to configure your server.

- Outline what are the key criteria to consider when selecting remote NTP servers
- Show how you would implement a test phase whereby you could assess the performance of various remote servers and the networks that connect them

[20]

Q3

(i) Describe in some detail how Voice over IP (VoIP) operates. Your answer should consider the following :

- Voice codecs
- Role and importance of Transport layer protocols RTP & UDP
- Impact of codec choice, packet loss, and M2E (Mouth to Ear) delay on Mean Opinion Score
- Role of PLC (Packet Loss Concealment) and FEC (Forward Error Correction) techniques

[20]

Show also how RTCP can be used to implement lip synch for Voice & Video over IP

[5]

(ii) As a senior QoS consultant, you are asked to outline a complete end-to-end infrastructural design for a potential Irish client company that wishes to implement an all-IP based conferencing (voice/video) system. The company will have two large facilities, in Dublin and Galway, each with their own LAN, and they will pay a third party via a Service Level Agreement (SLA) for use of an intermediate WAN.

Your design should address the following challenges:

- How QoS will be achieved across company LANs
- How QoS will be delivered across intermediate WAN. You can assume that the WAN provider uses DiffServ in its IP network.

[15]

Section B

Q4

(i) How can the Hamming (7, 4) code be used to encode 8-bit data? What error correcting and error detecting capabilities does the resulting encoding scheme have?

[10]

(ii) Consider you are a member of a development team responsible for the control software of a washing machine. The software is controlled by a scheduler based on the cyclic executive approach. It controls 3 tasks with cycle times of 50 msec, 75 msec and 100 msec as shown in Table 1 below. The execution time of each task is well below its cycle time.

Task	Period (msec)	Exec Time (msec)
A	50	10
B	75	10
C	100	10

Table 1

(a) Using (pseudo and/or C) code prototype a timer-interrupt-controlled cyclic executive for the above task schedule. Your answer must include an implementation of the timer-interrupt service routine.

[15]

(b) The washing machine hardware creates asynchronous interrupts that are handled by the control software via interrupt service routines.
What is the potential issue here in regards to meeting the above cycle time constraints? Discuss solutions to solve this issue. Use examples to illustrate your answer.

[10]

(c) Occasionally task A overruns (e.g. its execution time extends to 60 msec).
Enhance your cyclic executive from part (a) of this question to detect such violations.

[5]

Section continues on next page.

Q5

(i) The function below is a simple prime number test. It basically checks if a given positive number *num* can be divided without remainder by a divisor with values between 2 and *num / 2*. The function returns a 0 if *num* is not prime and a 1 otherwise:

```
int isPrime(unsigned int num) {
        unsigned int loop, end;
        end = num / 2;
        if (num == 1) {
           return 0;
        }
        else
        {
            for (loop = 2; loop <= end; loop++) {
                if (((num / loop) * loop) == num) {
                    return 0;
                }
            }
        }
        return 1;
}
```

Perform a WCET (Worst Case Execution Time) *estimation* of the above algorithm. You can assume the following:
- (unsigned) integer values are 16-bit wide thus you can calculate the maximum value of *num*
-All elementary (numeric, logical, etc.) operations above require one CPU cycle each.
- Each CPU cycle takes 1 microsecond (e.g. one millionth of a second).
- All variables are kept in registers (you can ignore memory data transfers).

[12]

(ii) Using the task set in Table 2 below:
- Calculate the overall *CPU utilisation U*.
- Determine the process schedule using the *RM scheduling algorithm*.
- Determine the process schedule using the *EDF scheduling algorithm*.
- Comment on the difference between both schedules.

Task	Execution Time	Period
1	10	50
2	20	100
3	20	150
4	80	200

Table 2

[16]

(iii) How does static software redundancy using *N-version programming* work? Using examples, distinguish between 3 voter types.

[12]

Section continues on next page.

Q6.

(i) The Hubble Space Telescope (HST) is a space telescope that was carried into orbit by a space shuttle in April 1990. Hubble is one of the largest and most versatile optical systems in space. It is well-known as both a vital research tool and a public relations asset for astronomy.
In part (a) and part (b) you will discuss various RTS aspects of this system.

(a) Hubble takes high-resolution digital images using its 2.4 m mirror, which are stored locally on a server, before being sent to Earth.
Identify environmental challenges for both the primary (e.g. RAM) and secondary (e.g. hard disk) server storage and discuss in detail how information redundancy on both (primary and secondary storage) level can be increased.

[12]

(b) One of the most important subsystems of the HST is its control momentum gyroscope (CMG) that monitors the position and orientation of the telescope, therefore holding it at a fixed attitude relative to the surface of the earth. The CMG consists of a sensor section (e.g. gyroscope) and a control section (e.g. computer).
Discuss 3 (hypothetical) system failure scenarios and outline how appropriate hardware and software fault tolerant techniques / redundancy can be used for their prevention.

[13]

(ii) What is meant by the *priority inversion problem* and how can it be solved? Use an example to illustrate your answer.

[15]